

THE FAUNAL SUCCESSION OF THE UPPER BERNICIAN

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(Plates XVI., XVII., XVIII.)

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I.

INTRODUCTION.

In this paper are set forth the results obtained by collecting in the calcareous beds of the Bernician or Lower Carboniferous series of Northumberland. The work, which occupied the greater part of a year (1907-8), had for its object an inquiry into the faunal succession of the Upper Bernician.

The scheme adopted for zoning was that used by Dr. Arthur Vaughan in his work on the Carboniferous Limestone formation of the South-West Province, and successfully applied by subsequent workers to other Carboniferous areas in Britain.

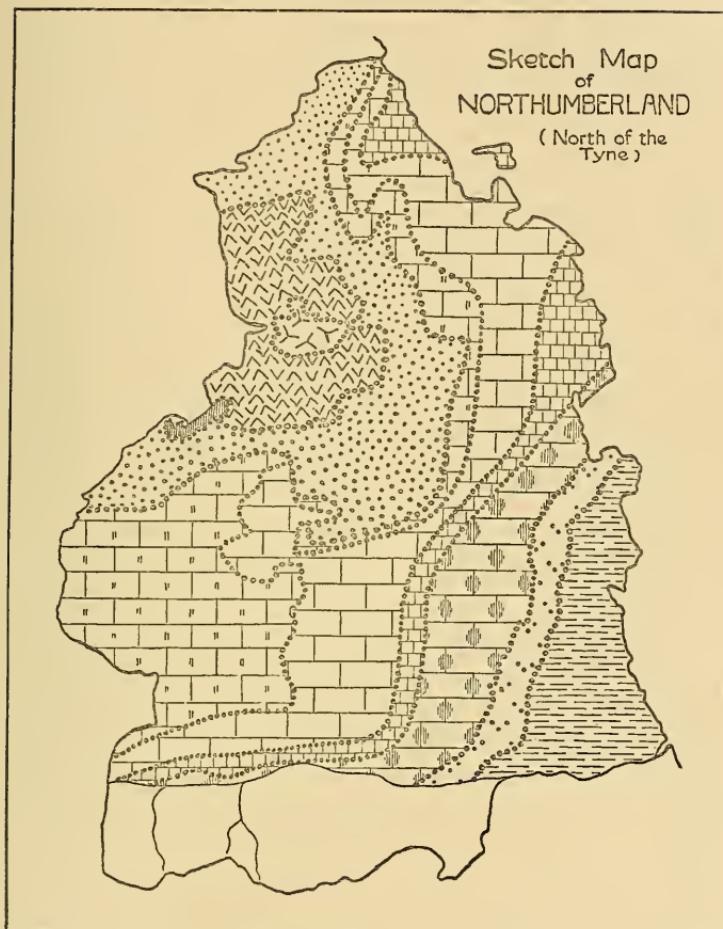
I take this opportunity of thanking those gentlemen who have so generously aided me in my undertaking. I am especially indebted to Prof. G. A. Lebour and Dr. Vaughan, to Prof. Lebour for his advice and encouragement whilst carrying out the field-work, and to Dr. Vaughan for determining the corals and for other valuable assistance. My thanks are also due to Dr. Wheelton Hind for naming the lamellibranchs, and to several members of H.M. Geological Survey, namely to Dr. Traquair for identifying the fish remains, to Dr. Kitchin and to Mr. R. G. Carruthers. Lastly I must express my great obligation to Mr. John Dunn, formerly of Redesdale, for allowing me access to his valuable collection of Redesdale fossils—the result of many years' careful collecting.

II.

THE BERNICIAN SERIES.

The Bernician series forms the upper, and by far the larger, division of the Lower Carboniferous sequence of Northumberland, and covers the greater part of the county. It is divisible into two groups, the upper or Calcareous Division and the lower or Carbonaceous Division. Below the Bernician strata lie the Tuedian beds, including under the term the Fell Sandstone series and the Cementstone group. The Northumberland succession, together with the Lower Carboniferous rocks north of the Tweed, occupies the northern extremity of the Carboniferous Limestone tract, which stretches from Lancashire and Yorkshire into Scotland.

The Carboniferous strata in Northumberland encircle the Cheviots on the south, east, and north, and dip from the volcanic inlier, so that the general strike forms a rough semi-circle round the igneous massif, nearest to which consequently lie the lowest beds. (See map.) In the south and east, the strata may be followed as continuous outcrops. In the districts round the volcanic inlier faulting has entirely destroyed the continuity of strike, but in the north it has spread out the scattered and repeated outcrops into belts, which run in the same direction as the general strike.



COAL MEASURES		TUEDIAN.....	
MILLSTONE GRI		SILURIAN.....	
CALCAREOUS GROUP	Upper Limestones Middle Limestones Lower Limestones	VOLCANIC.....	
CARBONACEOUS GROUP		GRANITE.....	

Geological Sketch-Map of Northumberland to show the Distribution of the Bernician Limestones.

The thickness of the Carboniferous Limestone series in Northumberland is difficult to estimate on account of excessive faulting and also owing to the great variations in thickness displayed by different members. It is probable that one division increases locally at the expense of another. The following figures given by members of H.M. Survey and others afford some idea regarding the thicknesses and variations of the groups; but they are only approximate.

		Tyne & Rede.	Coquet.	Tweed.
Bernician.				
Calcareous Division	...	4000?	?	1700
Carbonaceous Division	...	2500	Thin.	900
Tuedian.				
Fell Sandstone Series	...	600	2000	600
Cementstone Group	...	600	1000	2500

Between the Coquet and the Tweed the Cementstone group thins out locally to a few hundred feet (300 or 400?).

The Bernician series is mainly built up of shales and sandstones, but interbedded among the argillaceous and arenaceous deposits are beds of limestone and coal. Calcareous horizons are found in both divisions of the series, but the beds in the upper contrast strongly with those of the lower. In the Calcareous Division the limestones are thick, truly marine, and constant, some of them traversing the whole length of the county. In the Carbonaceous they are thin and impure, and often contain rootlets of *Stigmaria*; a few marine limestones make their appearance in the south. It is with the upper limestones that this paper is solely concerned, and my investigations were restricted to the country north of the Tyne.

South of Northumberland the Upper Bernician is mainly represented by the Yoredale rocks; the basal limestones, together with the Carbonaceous Division, are equivalent to

the Great Scar Limestone series. The higher Yoredale strata disappear as they are followed southward; till in Wharfedale the Millstone Grit comes almost immediately upon the Main (= Great) Limestone.

III.

PHYSICAL CONDITIONS PREVAILING DURING THE DEPOSITION OF THE SERIES.

This series of thick detrital accumulations, containing numerous beds of coal and frequent interpolations of calcareous strata, could only have been formed in the proximity of land, and under very varying conditions, involving continuous oscillation of the sea floor and repeated change in geographical relationships. The rate of accumulation of sediment must at one period have exceeded the rate of subsidence, so that the sea became so silted up as to form a swamp in which grew the jungles that formed the coal seams. Rapid submergence followed, and these vegetable accumulations often became the floor upon which the calcareous deposits were laid down. The limestones were deposited near enough to the coast to allow frequent invasions of fine sediment, as indicated by the numerous shaly partings and interbedded shales.

IV.

STRATIGRAPHICAL SUBDIVISIONS.

The limestones of the Calcareous Division may be divided into three groups. The limestones above the Little Limestone, which occupy the south and east of Northumberland and which thin out towards the north, form the Upper Group; the Middle Group comprehends those thick and continuous beds which can be followed right across the county, and includes the Great Limestone; whilst to the Lower Group belong the limestones of the Calcareous Division below the Eelwell Limestone.

Table I.
THE PRINCIPAL LIMESTONES OF THE UPPER BERNICIAN OR CALCAREOUS DIVISION.

	Tyne District.	Alnwick District.	Lowick and Scremerton District.
UPPER GROUP.	Fell Top Limestone. *Robshengh Limestone. *Thornborough Limestone. *Corbridge Limestone.	Fell Top Limestone (Alnmouth)	
			Great or Dryburn Limestone. Lowdean Limestone.
			Acre Limestone. Eelwell Limestone.
MIDDLE GROUP.	Little Limestone. Great Limestone. Four Fathom Limestone. Three Yards Limestone. Five Yards Limestone. Scar Limestone.	Great Limestone. Eight Yards Limestone. ? Six Yards Limestone. ? Nine Yards Limestone.	
LOWER GROUP.	Cockle Shell Limestone. Single Post Limestone. Tyne Bottom Limestone. Number of thin limestones. Fourlaws Limestone. Redesdale Limestone. Redesdale Ironstone Shale.	Cockle Shell Limestone. Single Post Limestone. Tyne Bottom Limestone. Number of thin limestones. Fourlaws Limestone. Redesdale Limestone. Redesdale Ironstone Shale.	Oxford Limestone. Woodend Limestone. Dun Limestone.

Besides the beds enumerated above are many thin calcareous horizons and local beds of considerable thickness.
* "Intercalated Limestones," of Professor Lebour.

V.

FAUNAL SUCCESSION, AND COMPARISON OF THE SAME
WITH THAT OF THE SOUTH-WEST PROVINCE.

The fauna throughout the Calcareous Group closely agrees with the fauna of the *Dibunophyllum*-Zone, the highest of the palaeontological divisions into which the Carboniferous Limestone series of the South-West Province (Bristol area) has been divided by Dr. Vaughan.*

The Bernician sequence yields a faunal succession which is capable of being divided into several marked horizons by means of corals and brachiopods, whilst a number of these horizons can be grouped together as characterised by the presence or abundance of some particular form or forms.

* A. Vaughan, "The Carboniferous Limestone Series of the Avon Gorge." Proc. Bristol Nat. Soc., 1906, ser. 4, vol. i, pt. ii, p. 74.

(See Table 2, p. 598).

Table 2.
PALEONTOLOGICAL HORIZONS OF THE UPPER BERNICIAN.

	Fell Top Limestone	IVc	Horizon of <i>Dibunophyllum aff. muirheadii</i> mut. cf. <i>Dib. ψ</i>	Saccammina carteri	
Dy	Robsheugh Limestone	IVb	Decadent and impoverished IVa Fauna	Productus β	Productus α
	Thornbrough Limestone			<i>Diphyphyllum</i>	Lithostrotion irregularis
	Corbridge Limestone			<i>Dibunophyllum muriheadii</i>	
D ₂₋₃	Little Limestone	IVa	Maximum of the Clisiophyllids		
	Great Limestone			Zaphrentid Phase	
	Four Fathom Limestone	III			
D ₂	Acre Limestone	II.	Lower D ₂ Fauna		
	Eelwell Limestone		<i>Lonsdaleia floriformis</i> enters		
D ₁	Oxford Limestone	I	D ₁ Fauna		
	Fourlaws Limestone				
	Redesdale Limestone	a	Shallow Water Phase		
	Redesdale Ironstone Shale				

Faunal Diagnoses*.

a.—Shallow water fauna, mainly lamellibranchs and certain brachiopods. Corals extremely rare, but *Dibunophyllum* θ has been found. The bed corresponds, approximately at least, in position to the concretionary beds immediately below D₁ of the South-West Province.

I.—(D₁).

Cyathophyllum murchisoni Ed. and H. very common.

Campophyllum derbiense.

Diphyphyllum subibicinum (M'Coy).

Carcinophyllum θ Vaughan.

Dibunophyllum θ Vaughan.

Clisiophylloid *Lithostrotion*.

Lithostrotion irregulare, as well as *Lith. junceum* and *Lith. portlocki* abundant, but as yet of no value in subdividing the D zone.

The fauna is comparable with that of D₁ in the South-West Province.

II.—(D₂).

II. contains forms found in D₂ of the South-West Province.

Lonsdaleia floriformis, Flem.

Dibunophyllum φ, Vaughan, and variants.

Lithostrotion irregulare and *Lith. junceum*.

III.—(D₂₋₃).

Representing in its main character a Zaphrentid phase.

Caninoid *Campophyllum*.

Zaphrentis near *enniskilleni*, E. and H.

* I am indebted for this portion of the paper to Dr. Vaughan, having embodied here his report on the corals submitted to him for examination. What slight alterations have been made were necessitated by the results obtained in subsequent investigations.

Caninia cf. *cornucopiae*, Nich.

Zaphrentis near *oystermouthensis*, Vaughan.

Zaphrentis constricta, Carruthers.

All the species above cited, with the exception of the last, are common in the D₂-3 Beds of Gower, South-West Province. Associated with the above are a few representatives of standard conditions D₂ and Dy: *Clisiophyllum* nr. *subimbricatum*, Thom.; *Koninckophyllum* *magnificum*, Thom. and Nich.; *Diphyphyllum lateseptatum*, M'Coy, and small variant.

IVa.—(Dy).

The main fauna represents standard conditions, and is extremely rich.

Dibunophyllum muirheadi, Thom. and Nich., and var. *D. splendens*. *Dibunophyllum* φ Vaughan and variants.

Koninckophyllum magnificum, Thom. and Nich., and numerous variants, including Dibunophylloid and Diphyphylloid varieties, e.g., *Diphyphyllum dianthoides* (M'Coy) and *Koninckophyllum* near *interruptum*, Thom. and Nich.

Diphyphyllum subibicinum, *D. lateseptatum*, and *D. concinnum*.

Lonsdaleia duplicata, Phill., and massive variant *L. conaxis*, M'Coy.

Also *Cyclophyllum* aff. *pachyendothecum*, Thom., which does not as yet possess any great value except as an index of D. (Some forms referred to *Aulophyllum* by Thomson are merely the young stages of the species cited above).

The fauna appears to represent a somewhat higher coral development than is found in the D₂ subzone of *Lonsdaleia floriformis* of the South-West Province, and consequently the beds are probably higher than the uppermost limestone of that area. Whenever both *Lonsdaleia floriformis* and *Lonsdaleia duplicata* are found, their maxima occur in the order above stated. In the S.W. Province the only massive *Lonsdaleia* is

L. floriformis. In Northumberland this species is rare, but *L. duplicata*, var. *conaxis*, is common.

The branching out into numerous variants, which both *Dibunophyllum* and *Koninckophyllum* exhibit, illustrates the instability which frequently precedes extinction.

Diphyphyllum reaches its acme of development in *D. dianthoides*, which is only foreshadowed in the D₂ of the South-West Province.

On the other hand one of the variants of *Koninckophyllum* is less highly developed than the D₂ species of the South-West Province, and is but little advanced on the D₁ form. Also *Cyclophyllum* aff. *pachyendothecum* is not much more advanced than the form in D₁.

The rich coral fauna which reaches its maximum development in IVa is represented by exaggerated and decadent forms in IVb and IVc.

IVb.—(Dy).

The tendency in the Dibunophyllids towards Aspidophylloid structure, already marked in IVa, reaches its highest development in the *Aspidophyllum* of the Thornbrough Limestone. *Dibunophyllum muirheadi* (typical) is, nevertheless, abundant in this limestone.* A new genus of Cyathophylloid *Dibunophyllum*, which occurs in the Robsheugh Limestone, shows convergence with *Caninia* cf. *cornucopiae* and *Densiphylum* in the regularly spaced interseptal intersections in the large medial area.

IVc.—(Dy).

The index of IVc is *Dibunophyllum muirheadi* (mut. cf. *Dib.* ψ). The genus *Koninckophyllum* is represented by a loose-structured, irregular and decadent form. The *Cyathophyllum* characteristic of the horizon has the vaulted vesicular tabulae of *Cyathophyllum regium*, but exhibits reversion in the fact that the tabulae are only partially replaced by vesicles.

* In Thornbrough Quarry, Corbridge.

This phenomenon is to some extent exhibited in certain specimens of the simple form of *Cyath. regium* from D₂ of the Avonian. The reduction in size and the conical form of the simple coral is an intimation of approaching inimical conditions.

The IV_b and IV_c fauna is probably the moribund representative of the Avonian coral fauna which reaches its acme in IV_a.

The following correlation of the Bernician with the Dibuno-phylum Zone of the South-West Province seems the most probable :—

	Northumberland	South-West Province
	Millstone Grit.	
Dy	{ IV _c . IV _b . IV _a .	Millstone Grit.
	III.	D ₂₋₃ .
	II.	D ₂ .
	I.	D ₁ .
	a.	Concretionary beds at top of S ₂ ?

N.B.—No attempt has been made in the above table to indicate the relative thickness of the various horizons.

VI.

THE BERNICIAN LIMESTONES, THEIR GEOGRAPHICAL DISTRIBUTION, STRATIGRAPHICAL CHARACTERS AND FAUNAL CONTENTS.

The Redesdale Ironstone Shale, Redesdale Limestone and Fourlaws Limestone.

Geographical Distribution.

These limestones are the most northerly of those running parallel to the Tyne. They cross the North Tyne south of

Wark and turn northwards. Their course being checked by a fault west of Sweethope Lough, they and their associated beds occur as faulted outliers among the Carbonaceous strata to the northward.

Redesdale Ironstone Shale.

Redesdale.

Stratigraphical Character.

Thickness about 30 feet. This shale is separated from the Redesdale Limestone by a thin but variable layer of black shale (1-2 feet) and a thin bed of sandstone, about 5 feet. The Ironstone Shale consists of a black argillaceous deposit with numerous bands of ironstone nodules and a layer of clay ironstone (4-6 inches).

Faunal Diagnosis.

CORALS:—Corals exceedingly rare, except *Alveolites*.

BRACHIOPODS:—*Productus undatus* and *Lingula scotica* characteristic forms. *P. concinnus* and *Orbiculoides nitida* very abundant.

LAMELLIBRANCHS:—This class is represented by a large number of species; the most plentiful forms being *Schizodus axiniformis* and *Nucula gibbosa*.

Faunal List:—

Dibunophyllum near θ , Vaughan.	Reticularia lineata (Dav.)
Fistulipora incrustans, Nich. and Foord.	Pugnax pleurodon β (Phill.) and young forms of <i>P. pleurodon</i> .
Alveolites.	Orthid.
Ceriopora interporosa (Phill.)	Orthotetid.
Heterotrypa tumida (Phill.)	Leptæna analoga (Phill.) var. distorta (Sow.)
Fenestella.	
Seminula ambigua (Sow.)	Productus corrugatus, M'Coy.
Dielasma gillingensis (Dav.)	Productus corrugato-hemisphericus
Spiriferina cf. laminosa (M'Coy.)	Productus antiquatus, Sow.
Martinia glabra (Mart.)	Productus pugilis, Phill.

Faunal List (continued).

Productus concinnus, Sow.	Sanguinolites plicatus (Portl.)
Productus scabriculus (Mart.)—P. cf. quincuncialis, Phill.	Sanguinolites striatogranulosus, Hind.
Productus punctatus (Mart.)	Sanguinolites tricostatus (Portl.)
Productus undatus, Defr.	Sanguinolites variabilis (M'Coy.)
Chonetes volva, M'Coy.	Sanguinolites V-scriptus, Hind.
Chonetes cf. crassistria, M'Coy.	Sanguinolites visetensis, de Kon.
Lingula mytiloides (Sow.)	Allorisma sulcata (Flem.)
Lingula squamiformis (Phill.)	Allorisma variabilis, Hind.
Lingula scotica (Dav.)	Conocardium aliforme (Sow.)
Orbiculioidea nitida (Phill.)	Bellerophon decussata (Flem.)
Limatulina desquamata (M'Coy.)	Bellerophon urei (Flem.)
Pterinopecten granosus (Sow.)	Loxonema murchisoniana, de Kon.
Aviculopecten semicostatus (Portl.)	Loxonema scalaroidea, Phill.
Aviculopecten incrassatus (M'Coy.)	Macrocheilina imbricata, Sow.
Pseudamusium redesdalense, Hind.	Naticopsis acuta, Sow.
Actinopteria persulcata (M'Coy.)	Conularia quadrisulcata, Sow.
Pinna mutica (M'Coy.)	Orthoceras annulatum, Sow.
Posidoniella elongata (Phill.)	Orthoceras attenuatum (Flem.)
Myalina pernoides (Portl.)	Orthoceras cylindraceum (Flem.)
Myalina redesdalensis, Hind.	Cyrtoceras rugosum (Flem.)
Myalina verneuillii (M'Coy.)	Glyphioceras diadema (Goldf.)
Nucula gibbosa (Flem.)	Glyphioceras truncatum (Phill.)
Nucula undulata, Phill.	Stroboceras sulcatum (Sow.)
Ctenodonta laevirostris (Portl.)	Archaeocidaris urei (Flem.)
Nuculana attenuata (Flem.)	Lepidodiscus lebourii ?, Sladen.
Nuculana brevirostris (Phill.)	Taxocrinus nobilis (Phill.)
Schizodus axiniformis (Phill.)	Several other crinoids.
Protoschizodus axiniformis (Portl.)	Dithyocaris dunni, Scoulen.
Protoschizodus fragilis (M'Coy.)	Dithyocaris glaber, Jones and Woodward
Cardiomorpha parva, Hind.	Dithyocaris tricornis, Woodward and Etheridge.
Edmondia arcuata (Phill.)	Teeth and scales of fish including :-
Edmondia pentonensis, Hind.	Gyracanthus.
Edmondia rufis, M'Coy.	Psammodus.
Edmondia sulcata (Phill.)	Chomatodus, etc.
Sedgwickia ovata, Hind.	
Sanguinolites clavatus (M'Coy)	

NOTES:—Mr. John Dunn, who collected in the shale for upwards of twenty years, found a single specimen of a simple coral, namely *Dibunophyllum*. The structure is not wholly preserved, nevertheless Dr. Vaughan has determined the species as *Dibunophyllum* near θ but showing variation towards *Dib.* ϕ .

Productus scabriculus Mart. (*quincuncialis*, Phill.) common. A mutation of the genus *P.* aff. *scabriculus* intermediate between C and D forms and converging towards *P. corrugato-hemisphericus*,* is also plentiful and characteristic of the shale. *Lingula scotica*, a large triangular species with fine laminose concentric lines of growth, is not only restricted to this horizon but has not yet been reported from any other locality in England.

More genera and species of lamellibranchs have been obtained from this bed than from the rest of the Bernician series. The Pteropod *Conularia quadrisulcata* is common at Bellingham, but true gasteropods are not very plentiful.

Redesdale Limestone.

Stratigraphical Character.

Thickness 17 feet (at Redesdale). The upper 6 or 7 feet are argillaceously inclined, otherwise the limestone is massive.

Faunal Diagnosis.

CORALS:—The corals are mainly typical of D₁, but contain forms belonging to D₂. *Dibunophyllum* θ , *Carcinophyllum* θ , *Cyathophyllum murchisoni*, *Diphyphyllum subbicinum* and Clisiophylloid *Lithostrotion* (all D₁ forms), common and highly characteristic. *Lithostrotion* (D₂), very abundant.

BRACHIOPODS:—Giganteid *Producti* (*Prod. a*) exceedingly numerous, otherwise the number of brachiopods is very much less than in the limestone above.

* Dr. A. Vaughan.

Faunal List:—

Dibunophyllum θ , Vaughan.	Dielastra sacculus (Mart.)
Dibunophyllum ϕ , Vaughan (DI form.)*	Dielastra vesicularis (de Kon.)
Carcinophyllum θ , Vaughan.	Reticularia lineata (Mart.)
Cyathophyllum murchisoni, Ed. and H.	Leptæna analoga (Phill.), var. distorta (Sow.)
Diphyphyllum subibicinum (M'Coy)	Giganteid Producti—Productus α and varieties.
Campophyllum murchisoni, Ed. and H.*	Productus corrugatus, M'Coy.
Clisiophylloid Lithostrotion.	Productus longispinus, Sow.
Lithostrotion irregulare (Flem.)	Productus punctatus (Mart.)
Lithostrotion junceum (Flem.)	Productus spinulosus, Sow.
Lithostrotion portlocki (Brom.) large and small varieties, also a Lons- daloid mutation.	Pinna flabelliformis, Mart.
Zaphrentis sp.	Leveillia puzo, L'Eveillé.
Alveolites.	Naticopsis plicistria (Phill.)
Athyris royssii (L'Eveillé.)	Naticopsis variata (Phill.)
	Platyschisma helicoides (J. de C. Sow.)

NOTES:—*Lithostrotion junceum* is not only most prolific in its growth but it is exceptionally well developed. The corallites are very long and very straight.

I obtained most of the corals in the above list from two small quarries at Birtley. *Dibunophyllum ϕ* and *Campophyllum murchisoni* (marked by an asterisk) were found in the bed of a burn near Elsdon, and some doubt exists as to the limestone from which they have been derived being the Redesdale Limestone. Both specimens are in Mr. Dunn's collection.

Fourlaws Limestone.*Stratigraphical Character.*

A dark-coloured compact limestone of at least 10 feet in thickness.

Faunal Diagnosis.

CORALS:—Not very plentiful.

BRACHIOPODS:—The Productids are represented by a large number of species, including *P. mesolobus* and *P. spinulosus*. *Productus α* exceedingly abundant. Papilionaceous *Chonetes* occur.

Faunal List:—

Faunal List (continued) :—

Naticula tabulata (Phill.)	Thyringoceras hibernicum, Foord.
Pleurotomaria carinata, Sow.	Vestinautilus cariniferus (Sow.)
Pleurotomaria decipiens, M'Coy.	Vestinautilus cf. crateriformis.
Platyschisma zonites, M'Coy.	Phillipsia derbiensis (Mart.)
Orthoceras gesneri (Sow.)	Phillipsia gemmulifera (Phill.)
Actinoceras giganteum (Mart.)	Phillipsia scabra, H. Woodward.
Ephippisceras bilobatum (Sow.)	Griffithides longispinus, Portl.
Nautilus ingens (Mart.)	Psammodus rugosus, Ag.
Nautilus nodiferus, Armstrong.	Petalodus hastingsii, Owen.
Sohenscheilus cf. crassiventer, de Kon.	Cladodus.

NOTES :—The Fourlaws Limestone is a richly fossiliferous bed; cephalopods and gasteropods are numerous. — All the forms in the above list are from the Waterfalls quarry near the village of Redesdale.

The faunal lists of the Fourlaws and Redesdale Limestones and the Redesdale Ironstone Shale have been considerably augmented by the addition of genera and species supplied by Mr. John Dunn's fine collection of Redesdale fossils. I have completed the list of the lamellibranchs from the list recently drawn up by Dr. Wheelton Hind.

The Woodend and Dun Limestone.

THE WOODEND LIMESTONE=THE HOBBERLAW LIMESTONE=
THE REDESDALE LIMESTONE.

Geographical Distribution.

The outcrops of the Woodend and Dun Limestones form with the Carbonaceous beds a belt girdling the Cheviots on the east and north, but separated from the volcanic mass by the Tuedian beds. Approaching the Tweed this belt bends round to the east and strikes out to sea south of Tweedmouth.

Stratigraphical Character.

Both compact beds; the Woodend is about 10 or 12 feet in thickness, the Dun about 6 feet.

Woodend Limestone.

Faunal Diagnosis.

CORALS :—

Lithostrotion maccoyanum, *L. irregulare*, and *L. junceum* abundant. *Dibunophyllids* not uncommon.

BRACHIOPODS :—*Productus a* very abundant. Semireticulate *Producti* plentiful.

Faunal List :—

Dibunophyllum sp.	Giganteid <i>Producti</i> (<i>Productus a</i>)
Lithostrotion irregulare (Phill.)	<i>Productus longispinus</i> , Sow.
Lithostrotion martini, Ed. & H.	<i>Productus semireticulatus</i> (Mart.) cf.
Lithostrotion junceum (Flem.)	<i>P. pugilis</i> , Phill.
Lithostrotion portlocki (Brönn.) var.	Aviculopecten.
maccoyanum, Ed. & H.	<i>Lithodomus lingualis</i> (Phill.)
Zaphrentis sp.	<i>Bellerophon</i> sp.
Syringopora sp.	<i>Dentalium ingens</i> , de Kon.
Favositoid coral.	<i>Euomphalus pentangulatus</i> , Sow.
Heterotrypa tumida (Phill.)	<i>Loxonema murchisoniana</i> , de Kon.
Seminula ambigua (Sow.)	<i>Orthoceras</i> sp.
Spirifer planicosta, M'Coy.	<i>Archaeocidarlis urei</i> (Flem.) (plates)

NOTES :—*Lithostrotion maccoyanum* occurs in large masses. *Productus semireticulatus* is represented by a small form closely approaching Phillip's *P. pugilis*.

This very fossiliferous bed needs much further exploration.

Dun Limestone.

The bed lies about 100 or so feet below the Woodend Limestone.

Lithostrotion junceum common, *L. irregulare* present. North of the Tweed, *L. maccoyanum* plentiful. *Clisiophyllids* rare ; small gasteropods not uncommon.*

* I am indebted for the information respecting the fauna of the Dun Limestone to Mr. Carruthers and to Mr. Bishop of Berwick. I have examined the bed near Spital but found no fossils.

The Calcareous Beds lying between the Scar Limestone and the Fourlaws Limestone, Tyne and Rede District.

Time has not allowed of a systematic examination of these limestones. In the country north of the Tyne are some ten or so of them, which, although little quarried, are exposed in the numerous burns. To the west of the North Tyne a number of quarries afford access to them.

These limestones mainly belong D₂, but the lowest of them yield forms characteristic of D₁.

The limestone which lies above the Fourlaws Limestone, and which is exposed in Shanks Kiln Quarry, contains in addition to forms common to D₁ and D₂:

Campophyllum derbiense,* Vaughan.

Cyathophyllum murchisoni, Ed. and H.

Through the kindness of Miss Dinning of Simonburn, I have had the opportunity of examining a number of forms she has collected from the shale exposed by one of the burns in that neighbourhood. The shale represents a low horizon in II of the table on p. 598, but occurs some distance above the limestone previously mentioned.

Dibunophyllids.	? Productus longispinus, Sow.
Lithostrotion (? irregulare) (Phill.)	Productus muricatus, Phill.
Lithostrotion maccoyanum,	Productus semireticulatus, Mart.
Ed. and H.	? Productus martini, Sow.
Fenestella sp.	? Chonetes buchiana, de Kon.
Rhabdomeson sp.	Aviculopecten dissimilis (Flem.)
Athyris planosulcata (Phill.)	Pseudamusium anisotum (Phill.)
? Seminula sp.	Amusium concentricum, Hind.
Reticularia lineata (Mart.)	Actinopteria persulcata (M'Coy.)
Rhipidomella michelini (L'Eveillé)	Pteronites latus (M'Coy.)
Orthotetids.	Pinna mutica (M'Coy.).
Productus α .	Archaeocidarlis urei (Flem.) (plates)
Productus latissimus, Sow.	Encrinital columns very numerous.

The lamellibranchs constitute a group of forms characteristic of the muddy conditions of deposition.†

* Found by Mr. John Dunn.

† Dr. Wheelton Hind.

Oxford Limestone.

Geographical Distribution.

Sea Houses, Lowick, and Scremerton districts.

Stratigraphical Character.

A compact bed of dark coloured limestone about 15 feet in thickness, rendered conspicuous by the presence of *Girvanella* in the form of red and black concretionary incrustations surrounding the corals and encrinite columns. (Pl. xviii., fig. 2).

Fauna.

Corals numerous; their poor condition however renders their determination difficult. Crushed Dibunophyllids abundant in the overlying shale in the Oxford Quarry (near Ancroft). *Dibunophyllum* nr. ϕ , *Lithostrotion*, Giganteid *Producti* (*Prod. a*) and other forms common.

The "Oxford" is perhaps the most highly encrinital limestone in the Bernician series, although the fragmentary columns of encrinites are abundant in all the calcareous beds.

Lonsdaleia floriformis has been found in a thin limestone 30 or 40 feet above the Oxford Limestone near Scremerton. This form appears to be rare in Northumberland, the author not having seen it in any of the limestones. Messrs. Carruthers and Mauff found it in the bed mentioned above, in December, 1908, and it has been recorded by H.M. Geological Survey from the Eelwell Limestone.

The "Posidonomya Bed."

Budle Bay.

In Budle Bay, between Bamburgh and Holy Island, a red calcareous shale is to be seen overlying a thickly bedded limestone. The shale, which is about 15 feet in thickness, passes upwards into sandstone.

The exact horizon of this shale is doubtful, but geographical and stratigraphical considerations point to its belonging to the Lower Limestone group.

Faunal List.

Chonetes cf. hardrensis (Phill.)	Sanguinolites augustatus (Phill.)
Lingula mytiloides, Sow.	Edmondia variabilis.
Do. squamiformis, Phill.	Bellerophon sp.
Productus scabriculus (Mart.)	Euomphalus pentangulatus, Sow.*
Rhipidomella aff. michelini (L'Eveillé).*	Goniatites sp.*
Orthotetid.	Phillipsia sp.*
Spirifer bisulcatus, Sow.*	Fenestella sp.*
Posidonomya becheri, Goldf.	Land plants.*
	Corals and crinoids absent.

NOTES:—This is the only bed in which I have found *Posidonomya*, but Professor Lebour speaks of them as common in several Bernician shales.

The Scar, and the Nine Yards, Eelwell or North Sunderland Limestones.

These two limestones are either the same bed, or very closely approximate to the same horizon.

Scar Limestone.

Geographical Distribution.

Tyne District. Closely associated with the Whin Sill.

Stratigraphical Character.

The limestone, as exposed in the neighbourhood of the Roman Wall, is a black crystalline rock, hardened and coloured by contact with the igneous intrusion. Fossils partially destroyed.

Faunal Diagnosis.

CORALS:—*Diphyphyllum lateseptatum* abundant; Dibuno-phyllids plentiful.

BRACHIOPODS:—*Productus giganteus*, Martin's species, common.

NOTES:—*Lithostrotion junceum* and *Diphyphyllum late-septatum* both form bands in the limestone. Spiriferids and other brachiopods plentiful.

Eelwell and North Sunderland Limestone.

Geographical Distribution.

Seen in the coastal section at Beadnell and at Sea Houses. (On account of a large anticline it appears on both sides of

* Recorded by Prof. Lebour. See Lebour—"Posidonomya Beds at Budle." Geol. Mag., Feb., 1885.

the latter village.) At Lowick it has been extensively quarried. Found at the coast again at Scremerton and Berwick.

Stratigraphical Character.

A fairly compact bed of limestone, with a few thin bands of shale interbedded in the calcareous mass. The strata frequently exhibit rolling and other irregularities.

Faunal Diagnosis.

CORALS:—A Caninoid *Campophyllum* and *Zaphrentis* aff. *enniskilleni* characteristic of the limestone at Beadnell and Sea Houses. *Diphyphyllum* aff. *lateseptatum* common at Lowick.

BRACHIOPODS:—*Productus giganteus*, near Martin's species, common.

Faunal List.

			Beadnell & Sea Houses.	Lowick.	Berwick.
Campophylloid Dibunophyllum	-	-	
Cyclophyllum aff. pachyendothecum, Thom.	-	-	
Diphyphyllum lateseptatum, M'Coy, and variants	-	-	
Lithostrotion junceum (Flem.)	-	-	
Caninoid Campophyllum	-	-	
Zaphrentis enniskilleni, Ed. & H.	-	-	
Heterotrypa tumida (Phill.)	-	-	
Fenestella	-	-	
Spirifer trigonalis (Mart.)	-	-	
Pugnax pleurodon (Phill.)	-	-	
Schizophoria resupinata (Mart.)	-	-	
Orthotetid	-	-	
Productus giganteus (Mart.)	-	-	
Productus longispinus, Sow.	-	-	
Productus semireticulatus (Mart.)	-	-	
Chonetes cf. hardrensis (Phill.)	-	-	
Lingula mytiloides, Sow.	-	-	
Streblopteria ornata (Eth.)	-	-	
Nuculana attenuata (Flem.)	-	-	
Edmondia sp.	-	-	
Sanguinolites plicatus (Portl.)	-	-	
Bellerophon sp. (large)...	-	-	
Euomphalus pentangulatus, Sow.	-	-	
Phillipsia eichwaldi, Fischer, var. mucronata, M'Coy...	-	-	

NOTES:—The “Eelwell” fauna is closely allied to that of the Acre Limestone, but contains fewer Great Limestone forms. The corals, which are very plentiful on the upper surface of the bed at the shore near Beadnell and Sea Houses, are thickened internally and their structure is often obliterated by calcareous matter. In the same locality *Prod. longispinus* and *Spirifer* near *trigonalis* form a band in the shale immediately above the limestone.

The faunal assemblage is an extensive one. From the Eelwell Quarry, Lowick, the late Rev. Edward Jenkinson obtained many of his specimens, now in the Sedgwick Museum, Cambridge. Fragments of encrinital columns are very numerous and frequently attain considerable thickness.

The thin limestone lying below the North Sunderland or Eelwell Limestone, and well exposed on the shore at Beadnell and near Sea Houses, possesses a fauna very similar to that of the thicker bed above it.

From the above locality I have obtained :—

<i>Cyclophyllum</i> aff. <i>pachyendothecum</i> .	<i>Zaphrentis</i> aff. <i>enniskilleni</i> .
<i>Lithostrotion junceum</i> .	<i>Productus longispinus</i> .
<i>Caninia</i> sp.	<i>Bellerophon</i> sp., large.
Caninoid <i>Campophyllum</i> .	

The Five Yards, Six Yards, and Acre Limestones.

The limestones referred to by these names, although occurring in the south, middle and north of the county respectively, are in all probability one and the same calcareous bed.*

Geographical Distribution.

Taken as one bed, the account of geographical distribution of the Great and Four Fathom Limestones equally applies to these limestones. The Five Yards occurs in the Tyne district; the Six Yards has been mapped from the Wansbeck to Beadnell, and the Acre is met with in the Lowick and Scrimston areas.

* Some writers regard the Three Yards Limestone as a southern representative of the Six Yards. There is no doubt as to the identity of the Six Yards and Acre.

Stratigraphical Character.

The Five Yards Limestone, although displaying numerous shaly partings, is free from thick argillaceous horizons. Thickness about 15 feet.

The Six Yards Limestone consists of some 18 or 20 feet of calcareous strata in thick "posts" separated by thin beds of shale. Beneath the limestone is a black shale, which at Little Mill measures some 18 inches in thickness, and contains lenticular masses of limestone and at the base a seam of coal.

The Acre Limestone is a massive limestone about 17 feet thick. Above the main bed is a thin band of calcareous rock intercalated in the overlying shale.

Faunal Diagnosis.

CORALS: —Characteristic forms: *Zaphrentis constricta*, very plentiful; *Zaphrentis* near *oystermouthensis*; *Cyathaxonia cornu*; *Caninia* nov. sp. All occurring in the Acre Limestone, Ancroft.

BRACHIOPODS: —*Spirifer planicosta* and *Spirifer wickensis*, common at Little Mill (Six Yards Limestone). *Productus* β and variants abundant, especially in the Six Yards.

<i>Faunal List.</i>		Five Yards L.	Six Yards L.	Acre L.
<i>Clisiophyllum</i> near <i>subimbricatum</i> , M'Coy	...	-		
<i>Dibunophyllum</i> sp.	-	-	
<i>Koninckophyllum magnificum</i> , Thom. & Nich.	...	-	-	
<i>Cyclophyllum</i> aff. <i>pachyendothecum</i> , Thom.	...	-	-	-
<i>Lithostrotion junceum</i> (Flem.)	-	-	
<i>Caninoid Campophyllum</i>	-		
<i>Caninia</i> sp. nov.	-		
<i>Cyathaxonia cornu</i> , Nich.	-		
<i>Zaphrentis</i> near <i>oystermouthensis</i> , Vaughan	...	-		
<i>Zaphrentis delanouei</i> , Ed. & H.	-		
<i>Zaphrentis constricta</i> , Carruthers	-		

Faunal List (continued).

			Five Yards L.	Six Yards L.	Acre L.
Zaphrentis constricta, towards <i>Z. delanouei</i> mut. parallela, Carruthers	...	...	...	-	-
Zaphrentis constricta approaching <i>Z. disjuncta</i>	...	...	...	-	-
Zaphrentis disjuncta, Carruthers	...	...	...	-	-
Zaphrentis (<i>Densiphyllum</i>) <i>costata</i> (M'Coy)	...	...	...	-	-
? Aulopora	...	...	...	...	1
Heterotrypa tumida (Phill.)	...	...	...	1	1
Fenestella	...	...	...	1	1
Rhabdomeson	...	...	...	1	1
Athyris planosulcata, var. <i>paradoxa</i> (M'Coy)	...	...	...	1	1
Athyris cf. <i>lamellosa</i> (Phill.)	...	...	...	1	1
Seminula ambigua, (Sow.)	...	...	...	1	1
Spirifer planicosta, M'Coy	...	...	1	1	1
Spirifer wickensis, Vaughan, n. sp.	...	...	...	1	1
Pugnax pleurodon (Phill.)	...	...	...	1	1
Schizophoria resupinata (Mart.)	...	...	...	1	1
Orthotetid	...	...	...	1	1
Latissimoid Producti (Prod. β and var.)	...	...	1	1	1
Productus giganteus (Mart.)	...	...	...	1	1
Productus aculeatus (Mart.)	...	...	...	1	1
Productus fimbriatus, Sow., fragment	...	...	...	1	1
Productus longispinus, Sow.	...	...	...	1	1
Productus longispinus, var. aff. <i>setosus</i> , Phill.	...	...	1	1	1
Productus muricatus, Phill.	...	...	...	1	1
Productus martini, Sow.	...	...	...	1	1
Chonetes cf. hardrensis	...	...	...	1	1
Nuculana attenuata (Flem.)	...	...	...	1	1
Bellerophon urei (Flem.)	...	...	...	1	1
Euomphalus cirrus, Sow.	...	...	1	1	1
Loxonema sp....	...	...	...	1	1
Macrocheilina sp.	...	...	...	1	1
Cyrtoceras rugosum, de Kon.	...	...	...	1	1
Orthoceras annulatum, Sow.	...	...	...	1	1
Orthoceras attenuata (Flem.)	...	...	...	1	1
Hydreionocrinus globularis, de Kon.	...	...	...	1	1
Phillipsia eichwaldi, Fischer	...	...	...	1	1
Saccammina carteri, Brady	...	...	...	1	1
Serpulites carbonarius, Salter	...	...	...	1	1

Zaphrentids determined by Mr. R. G. Carruthers.

NOTES.—*Cyathaxonia cornu* and *Caninia nov. sp.* are restricted to the Middle Skateraw Limestone in the Dunbar district, whilst *Zaphrentis* near *oystermonthensis* is abundant at that horizon. These facts support the correlation of the Acre Limestone and the Middle Skateraw Limestone made by Gunn and Bennie.*

Saccammina carteri is rare in the Five Yards Limestone, but forms a conspicuous band in the Six Yards and Acre Limestones (cf. Four Fathom Limestone). When, as often happens, the matrix containing the foraminifera has perished, the mass has the appearance of coarse oolitic limestone.

The shale at the base of the Six Yards Limestone in the Little Mill Quarry yields almost all the forms recorded here, whilst most of the Acre Limestone forms were found in the shale above the main calcareous bed at Ancroft. *Chonetes cf. hardrensis* is exceedingly abundant in the latter shale. *S. carbonarius* was obtained at Snab Leazes Quarry near Alnwick.

The Four Fathom Limestone.

(=Eight Yards Limestone of the Alnwick District and the Lowdean or Sandbanks of the Lowick and Scremerston area.)

Geographical Distribution.

Same as that of Great Limestone.

Stratigraphical Character.

This bed shows great structural change as it is followed from the south-west to the north. At Haltwhistle it consists of over 40 feet of limestone remarkably free from argillaceous intercalations, but contains numerous siliceous layers and nodules of chert. Round Alnwick the Four Fathom Limestone is about 30 feet in thickness and is composed of two calcareous members separated by a band of black shale three and a half feet in thickness. In the numerous chertose bands the upper

* R. G. Carruthers,

member resembles the Haltwhistle facies, but the lower member is built up of thickly bedded strata separated by thin layers of shale. The incomplete exposures between Haltwhistle and Scots Gap exhibit these thick calcareous "posts." In the north, the character of the lower member prevails throughout the bed, but the limestone is strongly argillaceous in the upper portion.

Faunal Diagnosis.

CORALS:—Corals rare and mainly pertaining to a Zaphrentid stage.

FORAMINIFERA:—*Saccammina carteri* is the most useful index of this and the underlying limestone.

Faunal List.

	Haltwhistle.	Haydon Bridge.	Elf Hills, Cambo.	Denvick Lane.	Cullernose Point.	Scremerston.
? <i>Carcinophyllum</i>	-	-	-	-	-	-
<i>Cyclophyllum</i> aff. <i>pachyendothecum</i> , Thom.	-	-	-	-	-	-
<i>Lithostrotion junceum</i> (Flem.) ...	-	-	-	-	-	-
<i>Caninia</i> sp. near <i>cornucopiae</i> , Nich.	-	-	-	-	-	-
Zaphrentis aff. <i>enniskilleni</i> , Ed. & H.	-	-	-	-	-	-
<i>Palaeacis cyclostoma</i> (Phill.) ...	-	-	-	-	-	-
<i>Fenestella</i>	-	-	-	-	-	-
<i>Seminula ambigua</i> (Sow.) ...	-	-	-	-	-	-
<i>Spirifer trigonalis</i> (Mart.) ...	-	-	-	-	-	-
<i>Martinia glabra</i> (Mart.)...	-	-	-	-	-	-
<i>Reticularia lineata</i> (Dav.) ...	-	-	-	-	-	-
<i>Pugnax pleurodon</i> ...	-	-	-	-	-	-
<i>Pugnax pleurodon</i> β , Phill. ...	-	-	-	-	-	-
<i>Rhipidomella</i> aff. <i>michelini</i> (L'Eveillé)	-	-	-	-	-	-
<i>Schizophoria resupinata</i> (Mart.) ...	-	-	-	-	-	-
Orthotetid	-	-	-	-	-	-
<i>Productus longispinus</i> , Sow. ...	-	-	-	-	-	-
<i>Productus punctatus</i> (Mart.) ...	-	-	-	-	-	-
<i>Productus</i> aff. <i>youngianus</i> , Dav.	-	-	-	-	-	-
<i>Productus scabriculus</i> (Mart.) ...	-	-	-	-	-	-
<i>Productus semireticulatus</i> , Mart.	-	-	-	-	-	-

Faunal List (continued).

			Haltwhistle.	Haydon Bridge.	Elf Hills, Cambo.	Denwick Lane.	Cullerhouse Point.	Scremerston.
Chonetes cf. hardrensis, Phill.	...	...					-	-
Chonetes cf. polita, M'Coy	...	...	-	-	-	
Orbiculoides nitida (Phill.)	...	...				
Aviculopecten sp.	...	...				
Edmondia sulcata (Phill.)	...	...	-			
Ctenodonta laevirostris, Portl.	...	...				
Nucula luciniformis (Phill.)	...	...				
Nuculana attenuata (Flem.)	...	...				
Lithodomus lingualis (Phill.)	...	...				
Grammatodon bistriatus (Portl.)	...	...				
Grammatodon reticulatus (M'Coy)	...	...				
Grammatodon semistriatus (M'Coy)	...	...				
Indeterminable lamellibranchs	...	...				
Bellerophon urei (Flem.)	...	-						
Bellerophon ? decussata (Flem.)	...	...				
Euphemus sp. ....	...	...				
Euomphalus pentangularis, Sow.	...	...				
Loxonema sulcifera, de Kon	...	...	-			
Loxonema rugifera, Phill.	...	...	-			
Macrocheilina ventricosa (de Kon.)	...	...	-			
Macrocheilina sp.	...	...	-			
Naticopsis ampliata (Phill.)	...	...	-			
Murchisonia sp.	...	...	-			
? Ptychomphalus sp.	...	...	-			
Small Gasteropods, doubtful forms	...	...	-			
Orthoceras attenuatum (Flem.)	...	...	-			
Orthoceras sp....	...	...	-			
Archæocidaris (spine)	...	...	-			
Hydreionocrinus sp.	...	...	-			
Phillipsia eichwaldi, Fischer, var. mucronata,								
		M'Coy						
Copodus spatulatus, Davis	...	..				
Serpulites carbonarius, Salter	...	...				
Saccammina carteri, Brady	...	...				

NOTES:—The Brachiopods comprise no very distinctive forms, but connect the Four Fathom Limestone with the Great Limestone above and the “Acre” below.

Saccammina carteri forms a band* in the limestone in the south of the county but is rare in the north (cf. the Acre Limestone).

The rare annelid cases *Serpulites carbonarius* are plentiful at Denwick Lane Quarry near Alnwick.

The overlying shale is usually very fossiliferous. The forms collected in the Cambo Quarry are all from this grey shale.

The Great Limestone.

(=The Dryburn Limestone of North Northumberland.)

From the extreme west this thick bed may be followed across Northumberland almost to the Tweed. Entering the county from Cumberland it runs parallel to the Tyne, never at any great distance from the river, till it approaches Watling Street. At Bewclay it turns northward and continues that course as far as Green Leighton, when it again changes its direction, this time to the north-east. The Great Limestone and the calcareous bed immediately below it are traceable as continuous outcrops onwards from Green Leighton to within half a mile of Lesbury. North of the Aln, faulting destroys the continuity of strike, but the disconnected outcrops with their various dips and strikes form a band, which advancing northwards from Alnwick occupies the coast between Howick Burn and Beadnell. Beyond Beadnell the lower beds (with a few of the middle beds faulted in among them) come into the coastal section. Appearing again on Holy Island, this band of Middle Limestones advances inland to Lowick, when faulting once more diverts its course, and after several repetitions the band finally strikes out to sea at Scremerston.

* I did not see the band at Haltwhistle, but it is very prominent at Haydon Bridge, Fourstones and Ryal.

Stratigraphical Character.

The Great Limestone in the south of Northumberland closely approaches a thickness of 50 feet, consisting of a thick and massive stratum of limestone of 19 feet ("Main Post") succeeded by a series of thin beds separated by shale ("Tumbler Beds.") In Mid-Northumberland although reduced in thickness the bed is more compact and freer from argillaceous intercalations, but it again thickens and becomes more shaly towards the northern boundary of the county, where it is known as the Dryburn Limestone. At Beadnell the limestone is strongly dolomitized.

Faunal Diagnosis.

CORALS:—*Dibunophyllum*, *Koniukophyllum* and *Diphyphyllum* reach their numerical maximum in this bed and display marked specialization and variation. *Lonsdaleia duplicata* and var. *conaxis* are common and widely distributed, and are restricted to the Great Limestone.

BRACHIOPODS:—No very distinctive forms. Latissimoid *Producti*, (*Prod. β* and variants) *Spirifer trigonalis*, *Reticularia lineata*, *Martinia glabra* and *Athyris planosulcata* very plentiful.

Faunal List.

	Haltwhistle District.	Fourstones and Chollerford.	Greenleighton District.	Newton on the Moor and High Whittle.	Beadnell.	Lowick and Scremerton.
<i>Dibunophyllum muirheadi</i> , Nich. & Thom. and vars.	-	-			-	-
<i>Dibunophyllum muirheadi</i> , var. <i>D. splendens</i> , Nich. and Thom.						-
<i>Dibunophyllum</i> near ϕ , Vaughan ...	-	-		-		
<i>Dibunophyllum</i> : Cyathophylloid, Campo- phyloid and other variants ...	-	-			-	-
<i>Cyclophyllum</i> aff. <i>pachyendothecum</i> , Thom.	-	-			-	

Faunal List (continued).

	Haltwhistle District.	Fourstones and Chollerford.	Greenleighton District.	Newton-on-the-Moor and High Whittle.	Beadnell.	Lowick and Scremerston.
<i>Koninckophyllum magnificum,</i> Nich. and Thom.	-	-	-	-	-	-
<i>Koninckophyllum near interruptum</i> Nich. and Thom.	-	-	-	-	-	-
<i>Diphyphyllum dianthoides</i> , M'Coy = <i>Koninckophyllum interruptum</i> ...	-	-	-	-	-	-
<i>Diphyphyllum lateseptatum</i> , M'Coy ...	-	-	-	-	-	-
<i>Lonsdaleia duplicata</i> , Phill. ...	-	-	-	-	-	-
<i>Lonsdaleia duplicata</i> , Phill., var. <i>conaxis</i> , M'Coy	-	-	-	-	-	-
<i>Campophyllum murchisoni</i> , Ed. and H., <i>Diphyphyllloid</i> mut. ...	-	-	-	-	-	-
<i>Zaphrentis constricta</i> , Carruthers MS. ...	-	-	-	-	-	-
<i>Zaphrentis constricta</i> near <i>Z. delanouei</i> , mut. <i>parallela</i> , Carruthers MS. ...	-	-	-	-	-	-
<i>Syringopora</i> sp. ...	-	-	-	-	-	-
<i>Alveolites septosa</i> (Flem.) ...	-	-	-	-	-	-
<i>Alveolites depressa</i> (Flem.) ...	-	-	-	-	-	-
<i>Palæacis cyclostoma</i> (Phill.) ...	-	-	-	-	-	-
<i>Heterotrypa tumida</i> (Phill.) ...	-	-	-	-	-	-
<i>Fenestella</i> ...	-	-	-	-	-	-
<i>Athyris</i> cf. <i>lamellosa</i> , L'Eveillé ...	-	-	-	-	-	-
<i>Athyris planosulcata</i> (Phill.) ...	-	-	-	-	-	-
<i>Seminula ambigua</i> (Sow.) ...	-	-	-	-	-	-
<i>Dielasma gillingensis</i> (Dav.) ...	-	-	-	-	-	-
<i>Dielasma vesicularis</i> (de Kon.) ...	-	-	-	-	-	-
<i>Spirifer trigonalis</i> (Mart.) ...	-	-	-	-	-	-
<i>Spirifer bisulcatus</i> , var. <i>calcaratus</i> (M'Coy)	-	-	-	-	-	-
<i>Reticularia elliptica</i> (Phill.) ...	-	-	-	-	-	-
<i>Reticularia lineata</i> (Dav.) ...	-	-	-	-	-	-
<i>Martinia glabra</i> (Mart.) ...	-	-	-	-	-	-
<i>Martinia ovalis</i> (Phill.) ...	-	-	-	-	-	-
<i>Pugnax pleurodon</i> (Phill.) ...	-	-	-	-	-	-
<i>Pugnax</i> cf. <i>acuminatus</i> (Mart.) ...	-	-	-	-	-	-
<i>Schizophoria resupinata</i> (Mart.) ...	-	-	-	-	-	-
<i>Leptæna analoga</i> (Phill.) ...	-	-	-	-	-	-

Faunal List (continued).

	Haltwhistle District.	Fourstones and Chollerford.	Greenleighton District.	Newton-on-the-Moor and High Whittle.	Beadnell.	Lowick and Scremston.
Orthotetids	-	-	-	-	-	-
Latissimoid Producti (Prod. β and var.) ...	-	-	-	-	-	-
Productus latissimus, Sow., fine ribs					
Productus giganteus (Mart.)					
Productus longispinus, Sow.	-	-	-		
Productus muricatus (Phill.)			-		
Productus near margaritaceus (Phill.)					
Productus semireticulatus (Mart.)					
Productus sulcatus, Sow.					
Productus scabriculus (Mart.)					
Productus punctatus (Mart.)					
Productus aff. fimbriatus (J. de C. Sow.)					
Productus aff. aculeatus (Mart.)					
Chonetes cf. hardrensis (Phill.)	-	-	-		
Allorisma sulcata (Flem.)		-			
Nucula gibbosa (Flem.)					
Lithodomus lingualis (Phill.)					
Pinna flabelliformis (Mart.)					
Bellerophon urei, Flem....	...					
Bellerophon sp.					
Euomphalus sp.					
Loxonema sp.					
? Polyphemopsis					
? Straparollus sp.					
Actinoceras giganteum (Sow.)					
Actinoceras striatum (J. Sow.)	-	-	-		
? Poterioceras	-	-	-		
Phillipsia sp.	-	-	-		
Poecilodus jonesii, M'Coy					
Psephodus magnus, M'Coy					
Saccammina carteri, Brady	-				

NOTES.—The coral fauna, although presenting standard conditions of deposition, nevertheless includes one or two representatives of the Zaphrentid phase, e.g., *Zaphrentis constricta*,* which occurs in the shale† above the limestone at Newton-on-the-Moor, together with *Palaeacis*.

For notes on the Clisiophyllids see page 632.

The corals are most abundant in the lower and massive portion of the limestone. At Lowick and Scremerston the corals are not only remarkable for their great numbers, but also on account of their excellent state of preservation. *Alveolites septosa* and var. *depressa* occur as thin sinuous bands often coalesced into masses. At Chollerford the base of the limestone is almost entirely formed of Alveolites.

Actinocerata frequently attain a great length. Specimens twelve feet long are by no means rare.

At White Houses a thin bed of sandstone four feet in thickness, intercalated in the shale a few feet above the Great Limestone, is full of *Productus latissimus* and bisulcate Spirifers.

The Little Limestone.

Geographical Distribution.

On entering the county from the west this bed runs along the Tyne valley till approaching Watling Street, when it changes its eastern course for a northern one. It turns slightly to the east again beyond Scots Gap and runs N.N.E. to within a mile of Brinkburn. North of this point it has not been mapped, though borings prove its presence. In the neighbourhood of Fallowfield several faulted outcrops occur.

Stratigraphical Character.

Fairly compact bed, but the upper portion is rather argillaceous in places.

Faunal Character.

No distinctive forms have yet been collected, the faunal

* A. Vaughan.

† I have been informed by Prof. Lebour that in a plantation near Hartington this shale was exposed as the bank of a burn and was full of small *Chonetes*,

assemblage presenting a much impoverished repetition of the Great Limestone fauna.

Faunal List :—

? <i>Dibunophyllid</i>	<i>Productus aff. aculeatus</i> (Mart.)
? <i>Diphyphyllum lateseptatum</i> M'Coy	<i>Productus concinnus</i> , Sow.
<i>Athyris planosulcata</i> (Phill.)	<i>Productus longispinus</i> , Sow.
<i>Seminula ambigua</i> (Sow.)	<i>Productus muricatus</i> , Phill.
<i>Bisulcate Spirifers</i>	<i>Productus scabriculus</i> (Mart.)
<i>Martinia glabra</i> (Mart.)	<i>Chonetes cf. hardrensis</i> (Phill.)
<i>Reticularia lineata</i> (Dav.)	<i>Bellerophon</i> sp.
<i>Schizophoria resupinata</i> (Mart.)	<i>Petalodus acuminatus</i> (Ag.)

NOTES.—*Productus concinnus* occurs in great numbers in the baked and crystalline rock seen above the basalt at Haydon Bridge. Most forms in the above list are from Fallowfield near Hexham.

The Corbridge Limestone.

Geographical Distribution.

The limestone is to be seen in the neighbourhood of Corbridge along several faulted outcrops. One of these runs through the town, and is exposed by quarries near the potteries. Another occurs near Aydon Castle. The closed outcrop of brecciated limestone at Halton Shields is undoubtedly the Corbridge Limestone. The bed sweeps round Stamfordham on the east, and has been mapped as far as West Belsay.* It has not yet been correlated with any of the upper limestones on the north of the Wansbeck.

Stratigraphical Character.

A compact, thinly-bedded limestone resembling the lower division of the Thornbrough Limestone. It rests upon sandstone. Thickness, 16 feet at Halton Shields.

Palaeontologically, as well as stratigraphically, the Corbridge Limestone resembles the lower member of the Thornbrough Limestone.

* The older geological maps give a very different interpretation of the outcrops from the later edition, and are undoubtedly wrong. The data collected for this paper support the results of the revision.

Alveolites septosa conspicuous but not abundant. *Seminula ambigua* and other small brachiopods common. *Producti* uncommon; the strong ribbed *P. latissimus* occurs. *Edmondia sulcata* very plentiful.

Faunal List.

<i>Alveolites septosa</i> (Flem.)	<i>Productus giganteus</i> var. nov. or abnormal form
<i>Fenestella</i>	<i>Productus longispinus</i> , Sow.
<i>Seminula ambigua</i> (Sow.)	<i>Lithodomus jenkinsoni</i> (M'Coy) †
<i>Productus latissimus</i> , Sow, coarsely ribbed.	<i>Edmondia sulcata</i> (Flem.) <i>Bellerophon</i> sp.

NOTES.—The *Alveolites* is found as small tumulary masses. The bed needs more investigation.

The Thornbrough Limestone.

Geographical Distribution.

Exposed in the north bank of the Tyne near Styford Hall, the limestone occupies a wide outcrop at Thornbrough to the east of Corbridge, and has been traced northwards by Stamfordham, through Belsay Park to a point beyond the river Blyth. The Stanton Limestone on the east of the village of that name is a continuation of the Thornbrough Limestone.

Stratigraphical Character.

This limestone retains for a distance of 19 miles the character it possesses at Styford, where a thick black shale is seen sandwiched between the two beds of limestone. Total thickness (average) about 18 or 20 feet. Central shale thickest at Styford and Stanton—the two extremities.

Faunal Diagnosis.

CORALS.—*Dibunophyllum muirheadi* and *Cyclophyllum* aff. *pachyendothecum* plentiful; *Lithostrotion* rare or absent.

BRACIOPODS.—*Productus latissimus* Sow. and latissimoid *Producti* (*Prod. β* and var.) abundant; *P. muricatus* plentiful; *P. scabriculus* common.

† Halton Shields.

<i>Faunal List.</i>	Styford.	Corbridge.	Belsay.	Stanton.
Dibunophyllum muirheadi, Thom. & Nich. (typical)		-		-
Dibunophyllum sp., poor		-		-
Koninckophyllum magnificum, Nich. and Thom.		-		-
Aspidophyllum		-		-
Cyclophyllum aff. pachyendothecum, Thom.		-		-
Alveolites septosa (Flem.)			-	-
Fenestella	-	-	-	-
? Hemitrypa sp.		-	-	-
Rhabdomesos		-	-	-
? Pemmatites sp.			-	-
Athyris roysii, L'Eveillé	-	-		-
Seminula ambigua (Sow.)	-	-	-	-
Dielasma (? hastata) (Sow.)			-	-
Bisulcate Spirifers towards S. trigonalis (Mart.)	-			-
Spiriferina sp.	-			-
Reticularia lineata (Dav.)	-			-
Pugnax pleurodon (Phill.)			-	-
Leptena analoga (Phill.)				-
Rhipidomella aff. michelini (L'Eveillé) ...				-
Schizophoria resupinata (Mart.) ...	-	-	-	-
Orthotetids	-	-	-	-
Latissimoid Producti (Productus β and variants)		-	-	-
Productus latissimus, Sow., coarsely ribbed		-		-
Productus giganteus (Mart.), cf. pl. 38, Davidson's Monograph		-		-
Productus longispinus, Sow.	-	-		-
Productus muricatus (Phill.)	-	-		-
Productus aculeatus (Mart.)		-		-
Productus punctatus (Mart.)		-		-
Productus scabriculus (Mart.)	-	-	-	-
Productus semireticulatus (Mart.), very large forms, cf. fig. I, pl. 43, Davidson's Monograph				-
Productus semireticulatus, including P. cf. pugilis (Phill.)	-	-	-	-

Faunal List (continued).

			Styford.	Corbridge.	Belsay †	Stanton.
Chonetes cf. hardrensis (Phill.)	-	-	-	-
Lingula squamiformis, Phill.	-	-	-	-
Aviculopecten sp.	-	-	-	-
Pinna flabelliformis (Mart.)	-	-	-	-
Allorisma sulcata (Flem.)	-	-	-	-
Edmondia expansa, Hind.	-	-	B	-
Nuculana attenuata (Flem.)	-	-	-	-
Grammatodon semistriatus (Mart.)	-	-	-	-
Euomphalus pentangularis, Sow.	-	-	-	-
Loxonema sp.	-	-	-	-
Orthoceras sp	-	-	-	-
Pleuronaiutilus sp.	-	-	-	-
Archæocidaris urei (Flem.) (plates)	-	-	-	-
Platycrinus rugosus, Miller (plates), cf. fig. in Portlock's Geology of London- derry, pl. 16, fig. 3	-	-	-	-
Rhodocrinus sp.	-	-	-	-
Phillipsia eichwaldi, Fischer	-	-	-	-

NOTES.—The *Dibunophyllum muirheadi* of this horizon presents typical forms of the species and strongly Aspidophyloid variants. Although I have only found the species at Thornbrough, it is hardly likely that the coral is restricted to this locality. The *Cyclophylla* attain considerable size. The whole horizon is richly fossiliferous, especially the central shale.

The Robsheugh Limestone.*Geographical Distribution.*

The Geological Survey have mapped this limestone from Whittle Dene Waterworks, Harlow Hill, to Belsay, east of the Hall.

Stratigraphical Character.

Thickness at Robsheugh 16 feet. The upper part of the bed is shaly.

Faunal Diagnosis.

CORALS.—*Cyclophyllum* aff. *pachyendothecum* abundant.

† Under Belsay are recorded one or two forms from Bygate (indicated by a B).

BRACHIOPODS.—*Productus giganteus*, Martin's typical form, is common.

Faunal List.

Cyclophyllum aff. pachy-	Latissimoid Producti (<i>Productus</i> β)
endothecum, Thom.	and variants
Aulophyllum	<i>Productus</i> aff. <i>aculeatus</i> (Mart.)
Cyathophylloid Clisiophyllid,	<i>Productus giganteus</i> (Mart.), very
genus nov.	large specimen
Lithostrotion junceum (Flem.)	<i>Productus semireticulatus</i> (Mart.)
Seminula ambigua (Sow.)	<i>Euomphalus pentangulatus</i> , Sow. <i>Edmondia sulcata</i> , Phill.

NOTES.—*Productus giganteus*: this very large variety is identical with those abundant in the Yoredale Limestones in Wensleydale and Swaledale, and closely resembles the figure in Davidson's Monograph, plate 38. The variety is finely ribbed, but the pedical valve has strong marginal folds, and the shell is very thick.

Fell Top Limestone.

Geographical Distribution.

The bed outcrops in Allendale and Hexhamshire. It passes beneath the Tyne in the neighbourhood of Bywell, but is not exposed. It runs N.N.E. by Harlow Hill, Stamfordham, and Mitford, and reaches the coast near Alnmouth.

Stratigraphical Characters.

Between the Tyne and the Pont the Fell Top Limestone is at least 20 feet in thickness, and consists of three calcareous beds separated by two argillaceous horizons. At Alnmouth it is represented by two thin seams of limestone, 18 inches and 9 inches respectively, divided by 6 inches of shale.

Faunal Diagnosis.

CORALS.—*Dibunophyllum muirheadi* (mut. cf. *Dib.* ψ) and *Phillipsastraea radiata* plentiful and characteristic; *Lithostrotion junceum* prolific, and *Lithostrotion portlocki* abundant; *Cyathophyllum regium*, towards *Cyathophyllum* ϕ , not uncommon.

BRACHIOPODS.—Latissimoid *Producti* (*Prod.* β) and varieties exceedingly abundant.

<i>Faunal List.</i>		Harlow Hill and District.	Alnmouth.
Dibunophyllum aff. muirheadi (mut. cf. Dib. ψ Vaughan)	-		
Cyclophyllum aff. pachyendothecum, Thom.	-		-
Koninckophyllum sp.	-		
Cyathophyllum aff. regium, Phill. (variant towards Cyath. ϕ , Vaughan)	-		
Caninia oystermouthensis n. sp., Vaughan	-		
Lithostrotion junceum (Flem.)	-		-
Lithostrotion portlocki (Bronn.)	-		
Phillipsastraea radiata (S. Woodward)	-		
Alveolites septosa (Flem.)	-		
Alveolites near depressa (Flem.)	-		
Fenestella	-		
Rhabdomesia and other Bryozoa	-		
Seminula ambigua (Sow.)	-		
Bisulcate Spirifers	-		
Orthids, crushed and imperfect forms. Probably including both Rhipidomella aff. michelini (L'Eveillé) and Schizophoria resupinata (Mart.)...	-		
Orthotetids	-		
Latissimoid Producti (Productus β and variants) ...	-		-
Productus cf. edelburgensis, Phill.	-		
Productus longispinus, Sow.	-		-
Productus muricatus, Phill.	-		
Productus punctatus (Mart.)	-		
Productus semireticulatus (Mart.)	-		
Chonetes buchiana, Phill.	-		
Chonetes cf. hardrensis, De Kon.	-		
Aviculopecten sp.	-		
Pinna flabelliformis (Mart.)	-		
Leiopteria (? laminosa) (Phill.)	-		
Edmondia sulcata (Phill.)	-		
Sanguinolites sp.	-		
? Eumicrotis sp.	-		
Conocardium sp.	-		
Bellerophon (? urei), Flem.	-		

Whilst carrying out the investigation of the higher beds I had the assistance on several occasions of Messrs. Herdman, Ingram, and McKay.

Faunal List (continued).

			Harlow Hill and District.	Alnmouth.
<i>Euomphalus pentangulatus</i> , Sow.	-	
<i>Loxonema imperidens</i> , M'Coy	-	
<i>Platyceras</i> sp. (young form of <i>P. neritoides</i> , Phill., or <i>P. vetustum</i> (Sow.)*	-	
<i>Phillipsia</i> sp.	-	
<i>Poecilodus jonesii</i> (M'Coy)	-	
The following additional forms are contained in Professor Lebour's lists of Fell Top Limestone fossils.†				
<i>Lingula squamiformis</i> , Phill.	-	
<i>Macrocheilus</i> sp.	-	
<i>Murchisonia</i> sp.	-	
<i>Orthoceras attenuatum</i> , Flem.	-	
<i>Poteriocrinus nuciformis</i> , M'Coy	-	
<i>Poteriocrinus</i> sp.	-	
<i>Griffithides farnensis</i> , Tate	-	
<i>Griffithides</i> sp.	-	
<i>Chomatodus cinctus</i> , Ag.	-	
<i>Petalodus acuminatus</i> , Ag.	-	

NOTES.—The shale, especially the upper bed, is conspicuous on account of the great quantity of encrinital columns, *Fenestella*, and crushed and fragmentary shells that it contains. These are of a white colour, and give an unmistakable identity to the bed. *Lithostrotion junceum* is present in most of the Bernician limestones, but it is particularly abundant in the "Fell Top" and the "Redesdale." The *L. junceum* characteristic of the latter bed possesses remarkably long and straight corallites, whereas that typical of the Fell Top Limestone is stunted and tortuous in growth. *Lithostrotion portlocki* is also abundant in the Redesdale Limestone, and the smaller variety *L. maccoyanum* occurs in

* Determined by Dr. Bather. This and several other forms in faunal list of this and the Thornbrough Limestone were collected by Mr. G. Weyman.

† * See Lebour—Geology of Northumberland, page 110.

very large quantity in the Woodend Limestone as well as in other Lower Bernician beds, but I have not found the species in the limestones between the Fell Top Limestone and the beds of the lower group. A piece of the carbonized remains of a plant occurred in a thick post of limestone in Crossedge quarry, Newton, near Corbridge.

VII.

DESCRIPTION OF CERTAIN CORALS AND BRACHIOPODS.

CORALS.

*Clisiophyllids.**

Dibunophyllum θ Vaughan.—Form cylindrical. Central area bisected by flexuous plate not specially thickened. The lamellæ are irregular and flexuous, and extend from the boundary of the area to the plate, with which they frequently inosculate. External area: very short minor septa and very open loose vesicles. No marked peripheral area, since all the septa extend almost or quite to the wall. The narrow cylindrical form from the Redesdale Limestone is probably this species, but the specimens obtained were badly preserved. The *Dibunophyllum* from the Redesdale Shale is a variant in which the mesial plate is difficult to trace, and in which the lamellæ inosculate.

In certain forms of *Dibunophyllum muirheadi* from Scremerston the vesicles of the external area are loose; these forms approach near to *Dibunophyllum* θ, but differ in the greater or less shortening of the lamellæ so that they do not reach the mesial plate.

Dibunophyllum muirheadi and the var. *D. splendens*, characteristic of the Dryburn Limestone, are large and cylindrical. The central area is on the plan of *Dibunophyllum* θ, but the vesicles are much more closely packed, especially in the case of *D. splendens*. The central area is completely bisected by a mesial plate, but the lamellæ which extend inwards from the boundary of the area do not usually reach the plate (a stage towards *Aspidophyllum*).

* Notes on the Clisiophyllids by Dr. Vaughan.

Dibunophyllum ϕ Vaughan.—This form, which differs from *Dibunophyllum* θ in the length of the minor septa that traverse the external area, and in the more strongly packed vesicles, as well as in its narrow corallum, occurs in the Great Limestone, and has been also obtained from a bed which is probably the Redesdale. In the South-West Province the species is most abundant in D₁, but extends to D₂.

Dibunophyllum muirheadi mut. (cf. *Dibunophyllum* ψ Vaughan).—This species is characteristic of the Fell Top Limestone. Compared with the type species the form is small and conical. The central area is typically Aspidophylloid, having a conspicuous plate projecting into the fossula and abruptly terminated before reaching the opposite side of the area. The lamellæ are conspicuously shortened. The external area is closely packed with vesicles, and the minor septa are longer than in the typical form of *D. muirheadi*, although never reaching the medial area. *Dibunophyllum* ψ differs in having longer minor septa, which traverse the whole external area, and less shortened lamellæ.

Aspidophyllum sp.—A typical *Aspidophyllum* (with shortened lamellæ, an indistinct mesial plate, and septa separated off into groups by wider interspaces) occurs in the Stamfordham Limestone at Corbridge.

Cyclophyllum aff. *pachyendothecum*.—The central area is enclosed by a loose wall, and is not so strongly cuspidate as in *C. pachyendothecum*, Thomson.

A Clisiophyllid of Cyathophylloid habit.—Central area not distinctly marked off from the medial area, simple and Dibunophylloid, with very inconspicuous tabular intersections and a few irregular lamellæ. Medial area broad and traversed by long, thickened, close-set septa; regularly spaced intersections in the interseptal spaces. External area narrow and occupied by thin extensions of the primary septa and by thin minor septa. Very minute vesicles occupy the septal interspaces; consequently, when mineralized, the external area appears as a dense narrow ring in which the true structure is obscured. Occurs in the Robsheugh Limestone. (Plate xvi., fig. 6).

Clisiophylloid Lithostrotion.—Thin septa, as in *Lithostrotion*, in the narrow external area. The central area is composed of a trabeculate columella entirely surrounded by a mesh of lamellæ and concentric intersections. Common in Dr of the South-West Province; not uncommon in the Redesdale Limestone. (Plate xvi., fig. 10).

Favositids.

Palaeacis cyclostoma (Phill.)—I obtained a number of these corals, each attached to the back of a *Chonetes*, from the base of the shale overlying the Great Limestone at the quarry close to High Whittle. Edwards and Haime in their monograph on Carboniferous corals (Pal. Soc., vol. 6, 1852) gave *Palaeacis cyclostoma* as the only species of its genus reported from the Carboniferous, the other known species belonging to the Silurian. Phillips (Geol. Yorks., II., p. 202, pl. 11, fig. 9) figures the species, and mentions Northumberland as the only known locality in which it is found.

There are two sets of specimens from Newton-on-the-Moor, one mile south of High Whittle, in the British Museum Catalogue, registered as B2700 and 50939*.

BRACHIOPODS.

Productus.

THE GIGANTEID GROUP.—In the Lower Bernician giganteid *Producti* are exceedingly abundant, and display important variation from the typical *Productus giganteus* of Martin. In the Middle and Upper beds they are much scarcer, and in place of the specialized forms which characterize the lower horizon the huge *Productus giganteus* and smaller latissimoid forms occur. The large species of Martin have very thick shells, fine striæ, and strong marginal folds.

Productus a..—This, the predominating type of the Lower Bernician giganteid group, differs from the typical form in being smaller, more globose, and in having a more acute beak. The striæ are somewhat coarser, but the marginal folds are inconspicuous. The ears are small, though distinct

* Kindly communicated to me by Dr. Bather.

from the rest of the shell, and are decorated by concentric wrinkles which extend on to the body of the shell. The spines are few in number. (Plate xvii., fig. 1).

THE LATISSIMOID GROUP.—The latissimoid *Producti* reach their numerical maximum and acme of specialization in the Middle and Upper Limestones, occurring in great numbers and possessing very wide range of variation, a range which has the typical *P. latissimus* as one extreme and circular and globose forms as the other. The most characteristic and abundant form is *Productus β*.

Productus β.—The variety is more oval in shape and is flatter than Sowerby's type of *P. latissimus*, but it agrees with Davidson's description of the species in the gradual passage of the body of the shell into the auriculate expansions. The shell, being finely striated, has on that account a smooth appearance, and is ornamented with sparsely distributed but stout and erect spines. (Plate xvii., fig. 2).

THE SEMIRETICULATE GROUP.—A variant agreeing with *P. pugilis* (Phillips) in respect to strong ridges upon the pedical valve towards the margin and the prominent spines it bears, is the prevailing type of the semireticulate *Producti* found in the Bernician sequence.

P. antiquatus is common in the Fourlaws Limestone and Redesdale Ironstone Shale.

FORAMINIFERA.

Saccammina carteri, Brady (Ann. and Mag. Nat. History, series ii., vol. vii., p. 177, pl. x.; Pal. Soc., vol. 34, 1876).—This small fossil is of the greatest importance as far as Northumberland is concerned, and was long used by the quarrymen as an index of horizon before the principles of zoning were understood. It is found in small quantity in most of the Lower and Middle Limestones, but is abundant in the Four Fathom and the Six Yards or Acre Limestones. The "spotted band," as the thin horizon is called at which it occurs in great quantity, migrates from the Four Fathom to the Acre Limestone northwardly. (Plate xviii., fig. 1).

VIII.

EXPOSURES.

		Quarter Sheet.
	FELL TOP LIMESTONE.	
Newton, near Corbridge	Crossedge Quarry. By the side of the road north of the church.	105 S.W. (New Series 20).
Harlow Hill ...	Quarries on both sides of the village (north and south).	105 N.W. (New Series 14).
Stamfordham ...	Stob Hill Quarry, near entrance to Cheeseburn Grange, by the road.	„
Milburn ...	Quarry west of Milburn Hall, by the road.	„
Mitford ...	Bed and banks of Pont, about two miles beyond Mitford.	„
Alnmouth ...	Exposure on the shore near Foxton Hall.	109 N.W. (New Series 6)
	ROBSHEUGH LIMESTONE.	
Robsheugh ...	Two quarries, one on the south and the other on the north side of Blackheddon Burn, near to Robsheugh (Farm). $1\frac{1}{2}$ miles southwest of Milburn, and close to the cross roads.	105 N.W. (New Series 14).
Belsay ...	Belsay Park—east of the Hall	... „
	THORNBROUGH LIMESTONE.	
Styford ...	Exposure in the north bank of the Tyne, half a mile east of Styford Hall.	105 S.W. (New Series 20).
Corbridge ...	Thornbrough Quarry, $1\frac{1}{2}$ miles due east of Corbridge, and situated south of Aydon. Several other exposures are to be seen in the Aydon neighbourhood.	„

EXPOSURES (*continued*).

		Quarter Sheet.
Bygate	...	Quarry half a mile north of Black Heddon near to the road. 105 S.W. (New Series 20).
Belsay	...	Quarry north of Belsay Castle, and by the side of the road which runs north of the Park. "
Stanton	...	Quarry one mile north of Stanton on the east side of the road. 109 S.W. (New Series 9).
		CORBRIDGE LIMESTONE.
Corbridge	...	Quarries north of the town near the Potteries; most recent exposure approached by Deadridge Lane, the other quarries lie to the west of the above. 105 S.W. (New Series 20).
Aydon	...	Aydon Castle Quarry, near White House, north of Corbridge. ,,
Halton Shields	...	Quarry in closed outcrop west of village, on the south side of the Military Road. 105 N.W. (New Series 14).
Stamfordham	...	A large but overgrown quarry south of the village, between Stamford- ham and Ousten; a small but newer one on the north, close to Mainsbank Farm. ,,
		LITTLE LIMESTONE.
Haltwhistle	...	Old quarry near Dean Houses, and close to the Military Road. 106 S.E. (New Series 19).
Haydon Bridge	...	Exposed in Whinstone quarry above the basalt half-a-mile east of Haydon Bridge station. By the side of the road. ,,
Fallowfield	...	Quarry together with colliery and barytes mine two miles and a half north of Hexham. 106 N.E. (New Series 13)

EXPOSURES (*continued*).

			Quarter Sheet.
Ingoe	...	Quarry west of village ...	105 N.W. (New Series 14).
		GREAT LIMESTONE, (= Dryburn of Lowick and North Northumberland).	
Haltwhistle	...	Two old quarries, on the south side of Military Road. Near Inn.	105 S.E. (New Series 19).
Chesterholm	...	Old quarry half-a-mile north of Vindolana.	„
Haydon Bridge	...	Several disused quarries' north of Haydon Bridge.	106 S.E. and 106 N.E.
Fourstones	...	Very large quarry, half-a-mile north- west of Fourstones station.	106 N.E. (New Series 13).
Chollerford	...	Two large quarries—"Black Pas- ture" and "Cocklaw"—both on the east of Chollerford road. "Black Pasture" is about half- a-mile from Chollerford station, and "Cocklaw" another quarter mile east of the first. The sand- stone workings above "Black Pasture" serve as a good guide.	„
Bewclay	...	Quarry by the side of Watling Street north of Stagshawbank.	„
Ryal & Mootlaw.		An extensive line of quarries mark the Great Limestone escarpment—a conspicuous feature of the land- scape.	105 N.W. (New Series 14).
Capheaton	...	Quarry south of Capheaton, about one mile west of Sandybraes.	„
Cambo	...	Quarry north-west of the village ...	„
Hartington	...	Quarry north of the village ...	109 S.W. (New Series 9).

EXPOSURES (*continued*).

		Quarter Sheet.
Green Leighton ...	Quarry three-quarters of a mile west of Longwitton station. A field-road leading to the quarry branches from the Rothbury road, a few yards north of the station.	109 S.W. (New Series 9).
White Houses ...	Quarry three-quarters of a mile south-west of Coldrife, and about a quarter of a mile east of railway.	"
Newton-on-the-Moor	Quarry close to the village ...	"
High Whittle ...	Quarry near farm and cottages bearing that name.	109 N.W. (New Series 6).
Shilbottle ...	Quarry north of village, near Townfoot Farm.	"
Ratcheugh ...	Several small exposures	"
Craster ...	Exposed on the shore ("The Carrs")	"
Embleton Bay ...	" "	"
Beadnell ...	Great Limestone forms Beadnell Point.	110 S.E. (New Series 4).
Lowick ...	Disused quarry, more than half-a-mile in extent, one mile north of Lowick crossing the Ancroft road. At the foot of the escarpment runs the Dryburn, hence the northern application—"Dryburn Limestone."	"
Scremerston ...	Quarry (under water) south of the large Sandbanks Quarry (Low-dean Limestone). Spoil heaps afford good collecting. Refuse from this quarry exceedingly rich in corals is to be found in the south end of the Sandbanks Quarry.	110 N.E. (New Series 2)

EXPOSURES (*continued*).

		Quarter Sheet.
	FOUR FATHOM LIMESTONE. (= Eight Yards Limestone of Alnwick district = Lowdean Limestone of the Lowick and Scremerston district).	
Haltwhistle	... Two quarries by the side of the Military Road. One near the Inn, the other close to Dean Houses.	106 S.E. (New Series 19).
Haydon Bridge	... Quarry two miles north of Haydon Bridge, by the side of lane leading to the Roman Road.	,,
Fourstones	... Quarry in the corner of the plantation west of the large quarries.	106 N.E. (New Series 13).
Ryal	... Quarry west of village near to the road.	105 N.W. (New Series 14).
Cambo	... Elf Hill Quarry (disused), near to the road leading to Knowesgate station, and close to the N.B. Railway.	,,
Denwick Lane	... Disused quarry between Denwick and Little Houghton, one and a quarter miles north-east of the former.	109 N.W. (New Series 6).
Howick and Dunstanburgh	The Four Fathom appears in the cliff immediately south of Cullernose Point; and running on the landward side of the Whinsill, which forms the cliffs between Cullernose and Dunstanburgh, strikes out to sea beyond Castle Point, forming the "Saddle Rock."	,,
Beadnell	... Exposed at the coast north of Beadnell,	110 S.E. (New Series 4)

EXPOSURES (*continued*).

		Quarter Sheet.
Holy Island	... Exposed in cliffs and shore on the north of Holy Island. There is also a quarry in the interior.	110 S.E. (New Series 4).
Scremerston	... Large quarry two and a half miles south of Spital, between railway and the coast. The bed is extensively exposed along the shore.	110 N.E. (New Series 2).
	FIVE YARDS, SIX YARDS, AND ACRE LIMESTONES.	
	FIVE YARDS LIMESTONE.	
Bardon Mill	... Quarry by the Military Road east of Borcovicus.	106 N.E. (New Series 13).
Fourstones	... Quarry south of Limestone Bank and one mile north of the Great Limestone quarry.	"
Walwick	... Quarry behind Wålwick Hall; also two small exposures west of Walwick by the side of the Military Road.	"
Lincoln Hill	... Quarry by the road side between Walwick and Humshaugh.	"
Bingfield	... Several small quarries near Bingfield.	"
	SIX YARDS LIMESTONE.	
Alnwick	... Snab Leazes Quarry near Ratcheugh, two and a half miles north-west of Alnwick.	109 N.W. (New Series 6).
Little Mill	... Quarry close to Little Mill station on the west side of the railway.	"
Howick	... Exposed in the cliff and on the shore south of Cullernose Point.	109 N.W. (New Series 6).
Beadnell	... Shore exposure	110 S.E. (New Series 4).

EXPOSURES (*continued*).

		Quarter Sheet.
ACRE LIMESTONE.		
Lowick	... Several quarries	110 S.E. (New Series 4).
Ancroft	... Quarry quarter of a mile east of village.	,"
Scremerston	... Quarry. Coastal exposure ...	,"
SCAR LIMESTONE.		
Limestone Bank..	Quarry south of Military Road. North of Fourstones.	106 N.E. (New Series 13).
Borcovicus	... Quarry north of Military Road, near the Roman Camp.	,"
EELWELL LIMESTONE		
Or North Sunderland Limestone.		
Beadnell	... Disused quarry partially filled with water ; also exposure in the cliffs. Both close to village.	110 S.E. (New Series 4).
Sea Houses	... , , , ,	,"
Lowick	... An extensive but old quarry, north of village. Several others in neighbourhood.	,"
Scremerston	... Exposure at the coast near Borewell station.	110 N.E. (New Series 2)
Berwick	... Exposure at the coast near Berwick Harbour.	,"
LOWER LIMESTONES OF SOUTH-WEST NORTH- UMBERLAND.		
	Although the number of the quarries giving access to these lime- stones is not great in the Tyne district, yet some exist. The burns however expose the various beds and afford collecting grounds. There are more quarries east of the North Tyne, including the Shanks Kiln Quarry east of Redesdale village.	

EXPOSURES (*continued*).

		Quarter Sheet.
OXFORD LIMESTONE.		
Sea Houses	... Exposure on the shore one mile south of Sea Houses.	110 S.E. (New Series 4).
Low Lynn	... Quarry one mile west of Beal station	„
Lowick	... Several old quarries near Lowick ...	
Oxford	... Very extensive quarry, but entirely filled with water, near cottages whose name the limestone has taken; one mile north of Ancroft.	110 N.E. (New Series 2).
Spital	... Exposure on the shore	„
FOURLAWS LIMESTONE.		
Birtley	... Quarry a mile and a half north of Birtley, near to the road leading from Birtley to Watling Street.	106 N.E. (New Series 13).
Redesdale	... Waterfalls Quarry, east side of Watling Street, two miles south of Redesdale.	„
„	... Fourlaws Quarry, half-a-mile south of Redesdale.	„
REDESDALE LIMESTONE AND IRONSTONE SHALE.		
Birtley	... Quarry south of village	„
„	... Cornacre Quarry half-a-mile north of Birtley.	
Tone Hall	... Small wayside quarry half-a-mile north of Tone Hall.	„
Green Rigg	... A line of small quarries marks the outcrop of the Redesdale Limestone, where it crosses Watling Street a little to the north of Waterfalls Quarry.	„

EXPOSURES (*continued*).

		Quarter Sheet.
Redesdale	...	106 N.E. (New Series 13).
Bellingham	...	"
		WOODEND LIMESTONE.
Belford	...	110 S.E. (New Series 4).
Lowick	...	"
-	...	Brownridge Quarry, two and a half miles south of Lowick, by the side of the Wooler road.
"	...	Highwood Quarry, two miles west of Bowsden, near the wood.
Spital	...	110 S.W. (New Series 3).
		Exposure in cliffs and on the shore ...
		DUN LIMESTONE.
"	...	Exposure in the cliff and on the shore.
Berwick	...	110 N.E. (New Series 2).
		Exposure along the shore between Berwick and Marshall Meadows.

EXPLANATION OF PLATES.

PLATE I.

UPPER BERNICIAN CORALS.

- Fig. 1. *Clisiophyllum nr. subimbricatum*, Thom.
Five Yards Limestone, Walwick (III.)
2. *Dibunophyllum nr. muirheadi*, Thom. and Nich.
Dryburn Limestone (IVa.)
3. *Dibunophyllum nr. muirheadi*, Thom. and Nich.
mut. cf. Dib. ψ —forma nov.
Fell Top Limestone, Harlow Hill (IVc.)

- Fig. 4. *Koninckophyllum magnificum*, Thom. and Nich.
Dryburn Limestone (IVa.)
- 4a. " " a less specialized variant.
Dryburn Limestone (IVa.)
5. *Aulophyllum* sp.
(= *Cyclophyllum nr. pachyendothecum*, Thom.)
Great Limestone, Harlow Hill (IVa.)
6. A *Clisiophylloid Cyathophyllum*.
Robsheugh Limestone (IVb.)
7. *Diphyphyllum subibicinum* (M'Coy).
Redesdale Limestone (I.)
- 8 & 8a. *Diphyphyllum dianthoides* (M'Coy).
(= *Koninckophyllum interruptum*, Nich. and Thom.)
Dryburn Limestone (IVa.)
9. *Carcinophyllum* θ , Vaughan.
Redesdale Limestone (I.)
10. A *Clisiophylloid Lithostrotion* \times 1.5.
Redesdale Limestone (I.)
11. *Densiphyllum costatum* (M'Coy) \times 2.
Six Yards Limestone, Snab Leazes Quarries, near Alnwick
(III.)

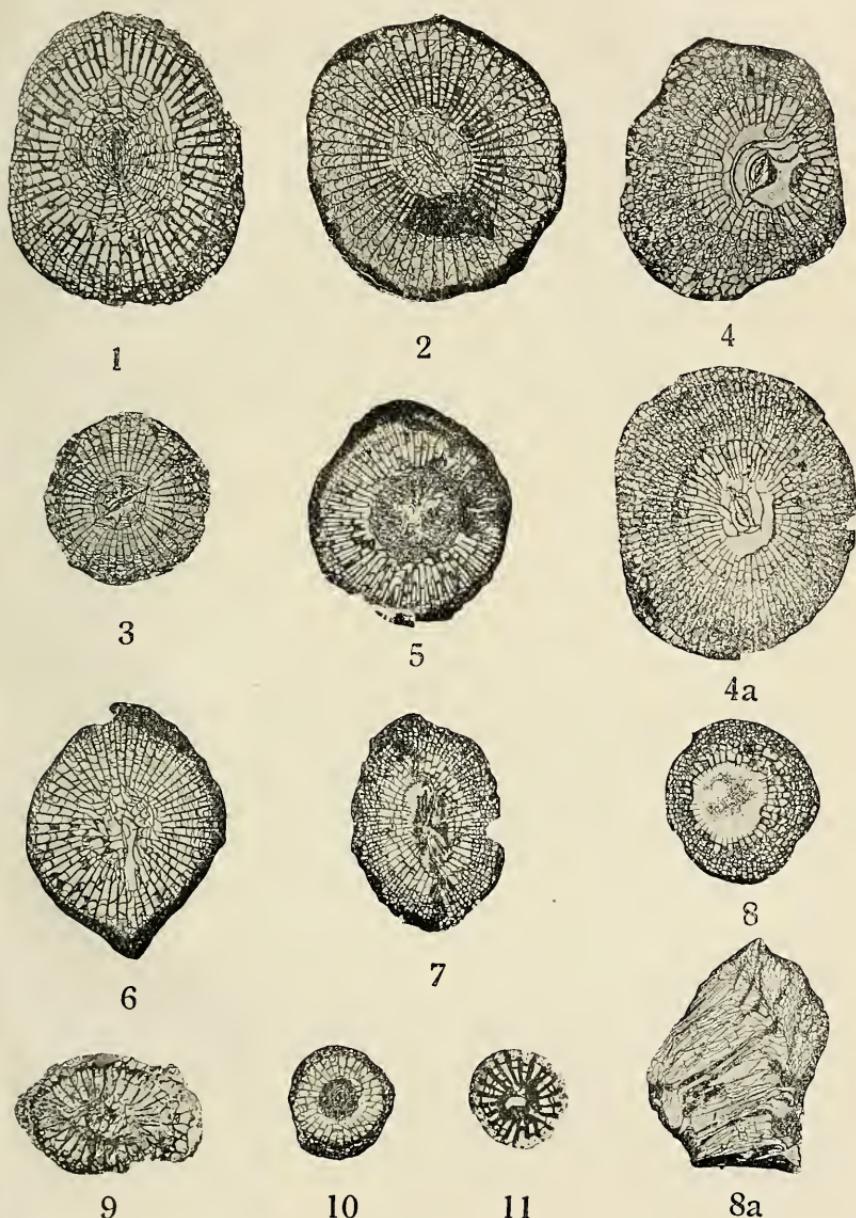
PLATE II.

UPPER BERNICIAN PRODUCTI.

- Fig. 1. *Productus* α , pedical valve \times .85.
Fourlaws Limestone (II.)
2. *Productus* β , pedical valve \times .9.
Fell Top Limestone (IVc.)

PLATE III.

- Fig. 1. *Saccanumina carteri*, Brady \times .66.
Acre Limestone, Scremerton (III.)
2. *Girvanella* encrusting corals and encrinal columns \times .9.
Oxford Limestone (II.)



UPPER BERNICIAN CORALS.

J. W. Tutterer, Photo.

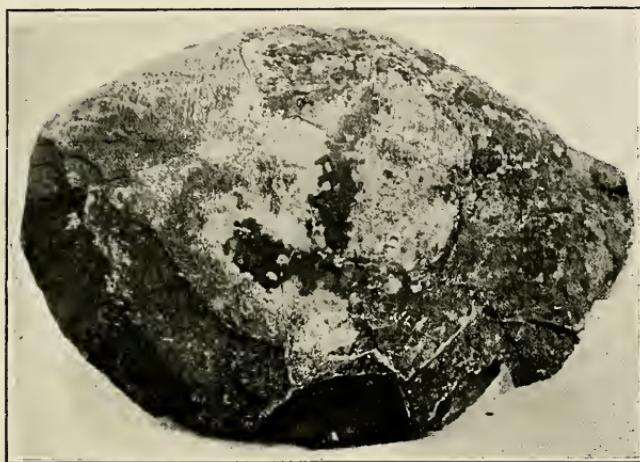


Fig. 2.

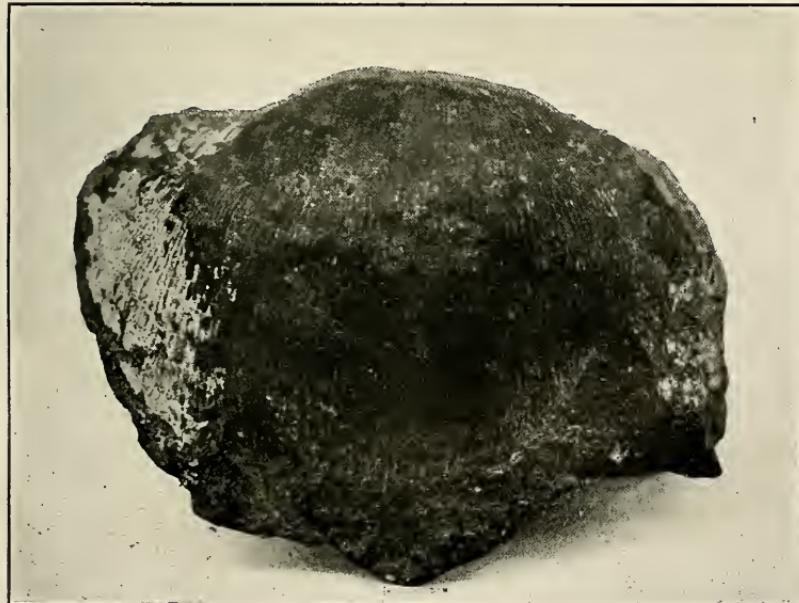


Fig. 1.

A. H. Harrow, Photo.

UPPER BERNICIAN PRODUCTI.

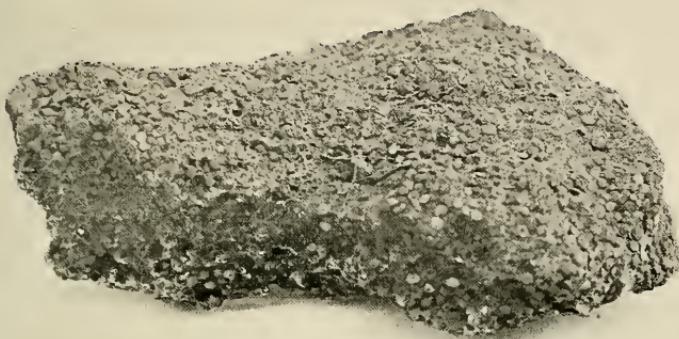


Fig. 1.



Fig. 2.

A. H. Harrow, Photo.

SACCAMMINA AND GIRVANELLA.

(UPPER BERNICIAN).

